Theme IV: new views concerning calculation and construction of bridges and structural work in reinforced concrete

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Theme IV.

New views concerning calculation and construction of bridges and structural work in reinforced concrete.

1) Since the Paris Congress of 1932 methods for the calculation of walled structures have been further developed. Solutions in accordance with the membrane theory are now available in all but a few cases. In the case of shell structures, where no direct solution by means of differential equations is possible a sufficiently accurate solution can usually be obtained by means of equations in finite differences. The problem of shells becomes considerably more difficult when bending moments are present, especially where these bending moments are not due to constraint around the edges but are necessary in order to satisfy the conditions of equilibrium. This is the case above all in freely supported cylindrical shells of simple curvature, whereas in the case of shells with compound curvature only tensile stresses are present as a rule. From the knowledge now available it is possible to calculate exactly the bending moments in these cylindrical shells not only under surface loads but also under a linear distribution of load or under isolated loads, whether for circular or any other forms of cylinder, but the calculation is laborious. Here, as in the case of the simple problem of slabs, there is a need for sufficiently accurate approximate solutions checked against rigorously calculated examples. In the construction of long span shells the problem of safety against buckling becomes of great importance. For the most important kinds of shell — particularly the circular cylindrical shell — this problem has already been solved, and can be treated with relatively little mathematical labour. In determining the safety against buckling, especially in the case of shells with simple curvature (cylindrical shells), deformation must be taken into account, as this plays a part which may be very considerable in the case of thin shells owing to the creep of the concrete.

2) An increase in the span of arch bridges is dependent on careful study of the shape of the arch axis, the variation in the resisting moment and the permissible stresses. The best possible equalisation of moment must be sought and tensile stresses avoided, account being taken of elastic and permanent strains in the arch, the abutments and the foundation. For this purpose it is necessary to know the modulus of elasticity of the concrete as a function of time and of the conditions under which the arch is to be constructed. In arches of box section special attention must be paid to the unfavourable conditions of stress resulting from the division of the arch into two separate slabs.

Progress in bridge construction is further dependent on the possibility of light forms of centreing which will remain true to shape over considerable spans. The method, which has been adopted with success in practice, wherein the centreing is loaded with only a portion of the weight of the arch, gives rise to conditions of strain in the latter calling for further elucidation in order that the degree of safety may be more exactly determined.

3) In beam bridges the adoption of pre-stressed reinforcement opens up a whole range of new possibilities, since in this way much greater spans can be obtained than in existing bridges while at the same time the dead load may be greatly reduced. Moreover it becomes possible to design beam bridges wherein little or no bending tensile stress will arise, even under unfavourable conditions of live load, so that the risk of dangerous cracks is avoided. By this method of design a simply supported beam can be designed with solid webs up to 80 m [262′ 6″] in span, simply supported beams with open webs up to 100 m [328′ 1″] span, and continuous beam bridges up to 150 m [492′ 2″] span.

Particularly favourable conditions may be obtained if the pre-stressed bars are so arranged that only concentric compressive forces will arise in the beam under dead load. The first step in the realisation of reinforced concrete bridges by these new methods has already been taken, in that a bridge of approximately 70 m [229′ 8″] span is now under construction, and the experience thus gained will be available for designing bridges of still greater span.

In these pre-stressed bridges great importance attaches to precise knowledge of the modulus of elasticity of the concrete, in order that the effects of creep and shrinkage may be eliminated.

If advantage is taken of this method, arranging the stirrups in such a way that the dead loading will give rise mainly to concentric compressive stresses alone and that no plastic bending will occur, the stresses in these stirrups may be correctly determined even if the modulus of elasticity is not exactly known. Otherwise the stresses in the pre-stressed bars in question must be measured with extensometers or by other means.